

UHI & human **heat-stress** values during
the July 2006
Portland, Oregon heat wave

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Outline

- Summary of PSU (D. Sailor) NSF project (funding source)
- Data
- Results
 - Synoptic forcing
 - Urban Heat Island (UHI) patterns
 - Heat Index (HI) values
- Conclusion

PSU NSF Multidisciplinary Project

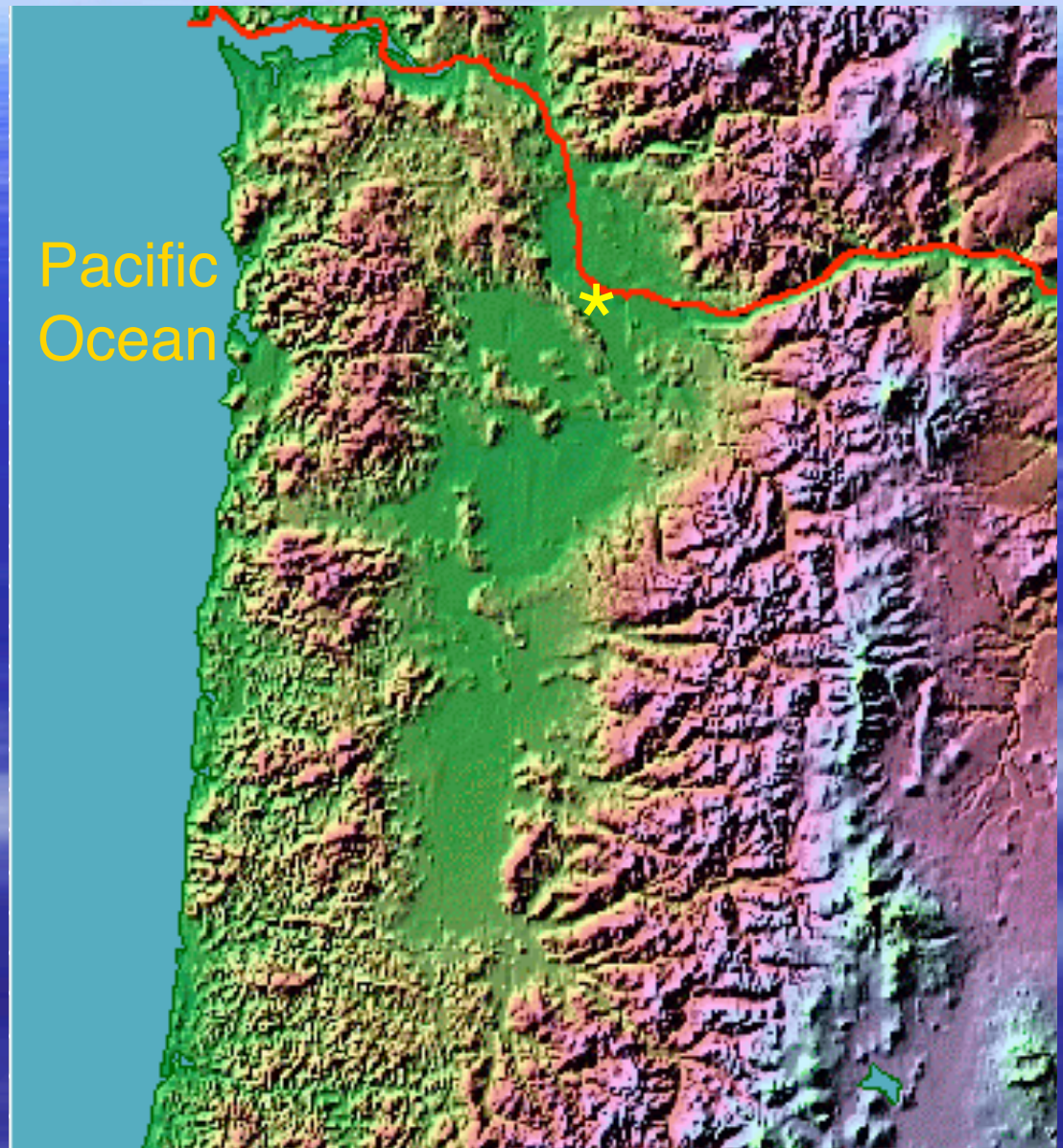
- 50% air pollution met & modeling (D. Sailor, H. Taha, & SJSU)
- 50% social science phone-bank outreach re air quality & heat wave health-warnings

SJSU Research Questions

- What were the **synoptic causes** of the 2006 Portland heat-wave?
- What were the **mesoscale variations** across the Portland area of
 - observed urban heat island (**UHI**) temperatures
 - calculated heat index (**HI**) values?
- How did mesoscale HI values **compare** with NWS HI values?

Portland, Oregon, shown as *

- in Willamette Valley
- urban area: 376 km²
- mean elevation (at Airport) = 15 m MSL



Portland Climate Summary

- **Winter:** Mild, cloudy **rainy** periods with good mixing & **SE winds (next table)**, punctuated by colder stagnant, light winds. Highs mostly in the 30s & 40s.
- **Spring:** **Transitional** time. March & April are wet and cool, while May & June are drier. Generally good mixing. Highs mostly in the 60s and 70s.
- **Summer:** Mild to **warm**, with high temps from 70s to 90s. Persistent **NW afternoon winds bring cleansing, cooling sea breeze**. Much **less rain** than other seasons.
- **Fall:** Autumn is **reverse of spring**, with many warm days in Sept. By mid-Oct, rains increase. Cooler temps, with afternoon highs in 50s & 60s. Stagnant periods between storms are frequent, during which fog can persist for several days.

Portland Wind Direction Frequencies (%)

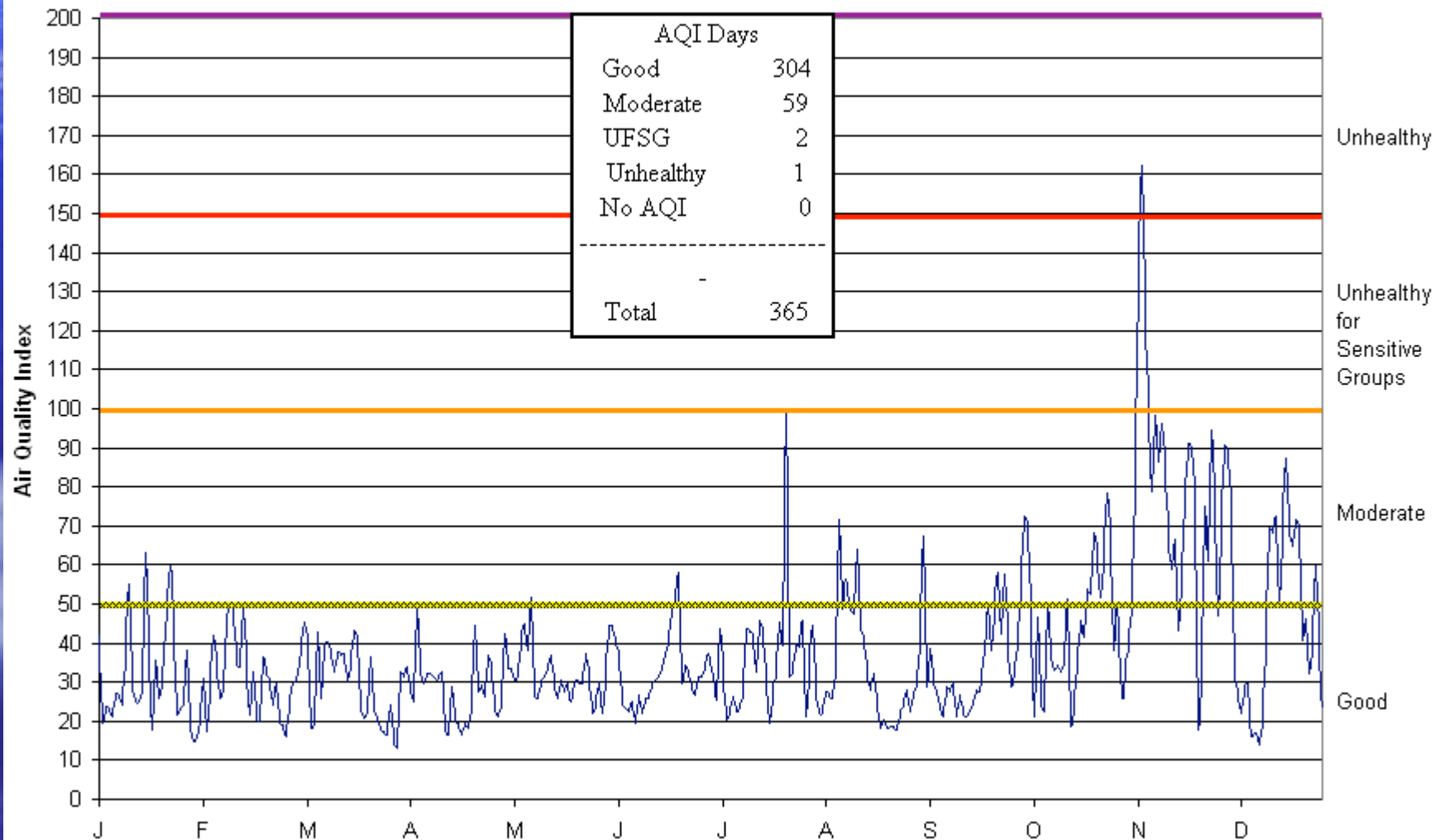
Period of Record: October 1940 - May 1999

month/ LST		Calm	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WS	W	WN	NW	NNW
Jan	07	12.4	1.3	0.6	1.4	2.5	7.8	23.4	12.6	4.3	8.0	8.2	3.8	2.1	2.7	3.4	2.9	2.2
	13	4.8	1.9	0.8	1.4	1.9	9.3	22.9	12.2	3.5	7.1	10.7	5.4	3.3	3.8	5.4	3.8	2.1
	19	9.1	0.8	0.4	0.8	2.0	8.3	31.4	14.5	3.4	7.5	7.9	4.3	1.9	2.3	2.3	1.9	1.2
Jul	07	10.6	12.9	4.2	2.5	2.1	2.0	3.2	2.1	3.0	4.5	3.2	1.6	2.1	3.1	8.0	16.1	18.7
	13	1.7	7.9	3.6	2.5	2.5	1.8	0.9	0.5	0.8	2.5	2.3	2.3	3.4	7.6	22.5	22.5	15.5
	19	1.2	9.9	1.3	0.5	0.8	1.4	1.0	0.8	0.4	1.4	0.9	1.0	1.9	2.9	7.5	31.3	36.6

SOURCE: NWS, Portland, Oregon (via Mike Voss, SJSU)

Portland Air Quality Index (AQI) for 2004

2004 Portland Area Air Quality Index
(Based on PM2.5, Ozone, and CO)



Improved PM: due to tighter controls & thus reduced emissions.

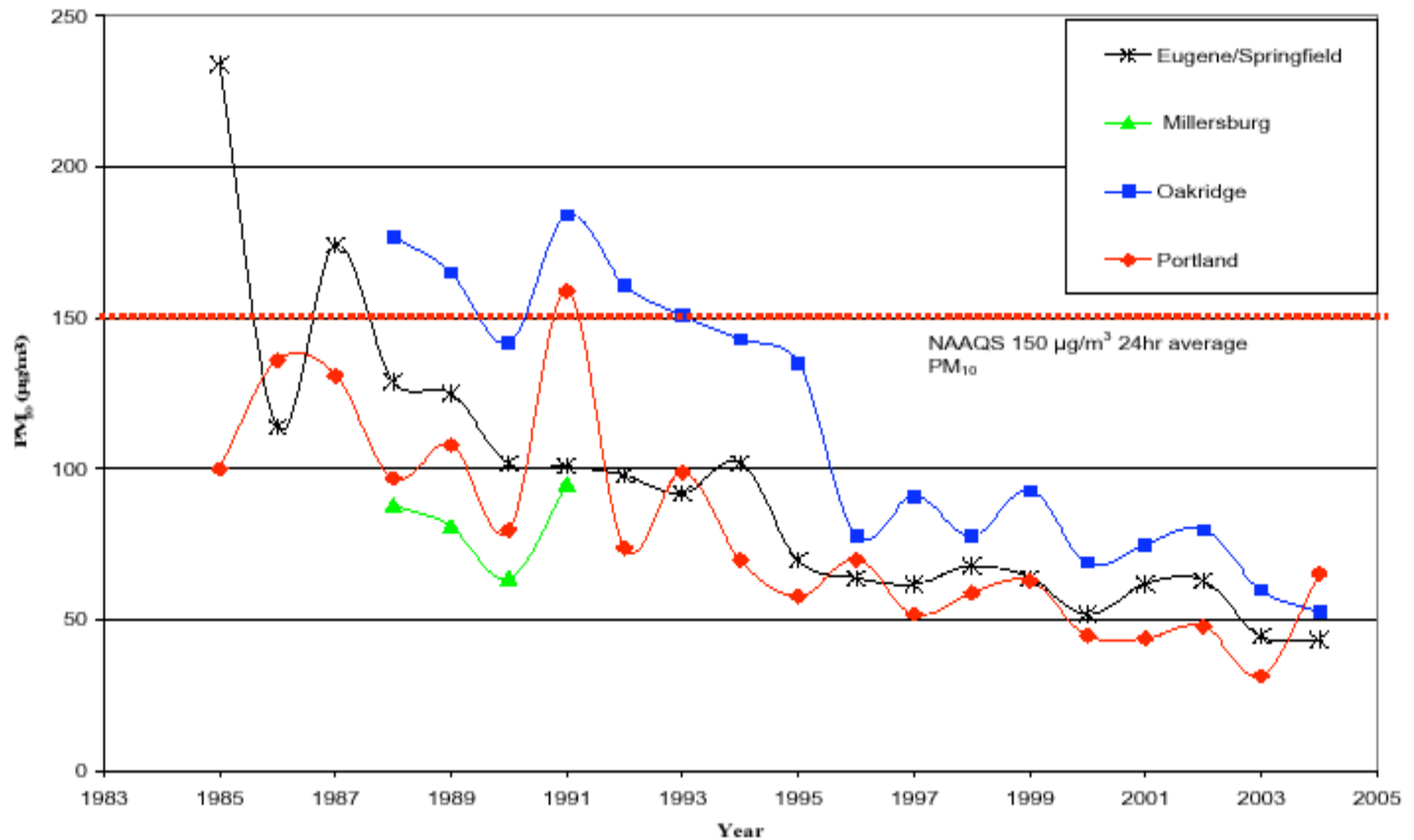


Figure 20a. PM₁₀ trend for NW Oregon cities using the second highest 24 hr average.

O_3 : drop smaller, as controls & reduced emissions have been offset by increased population

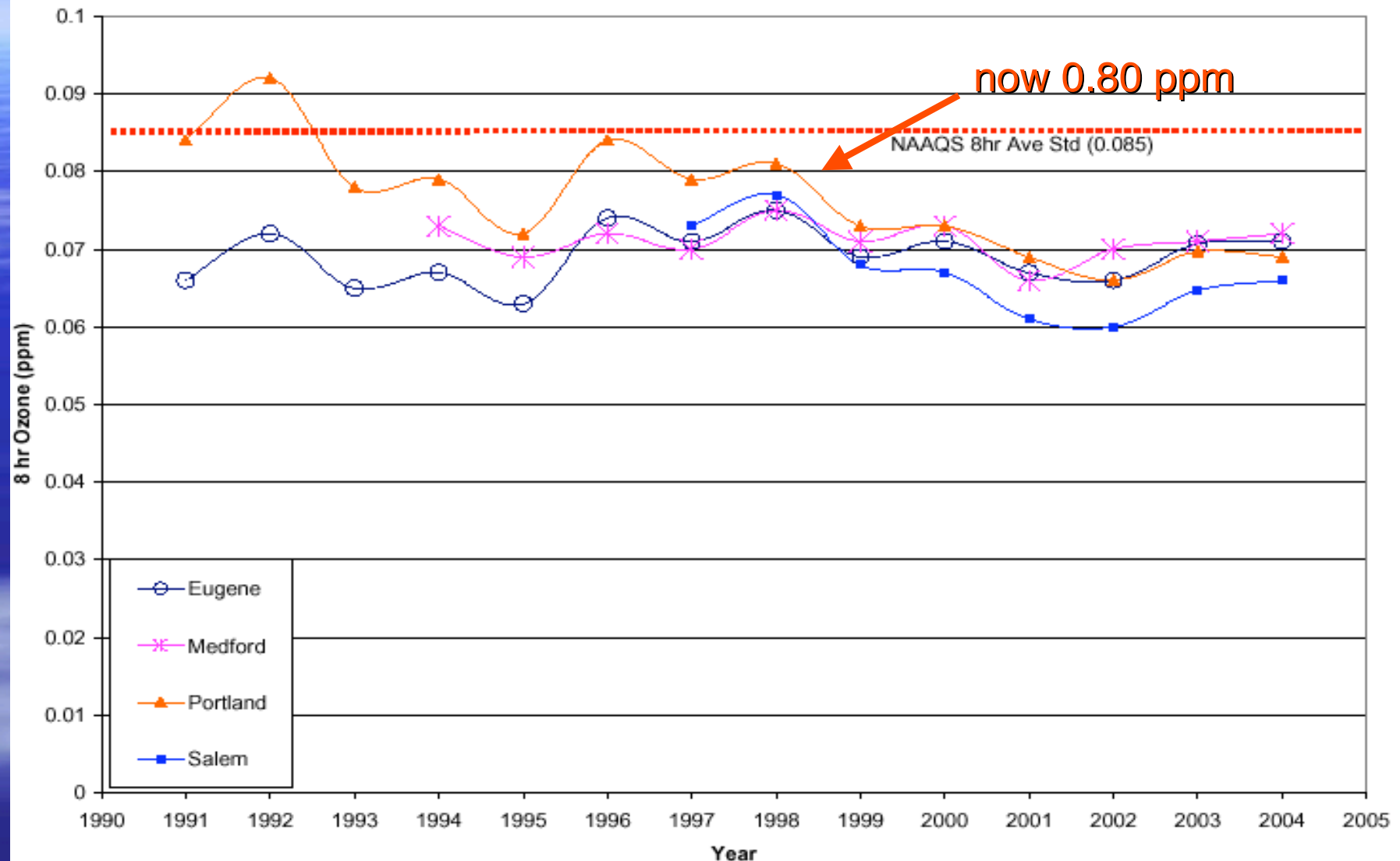
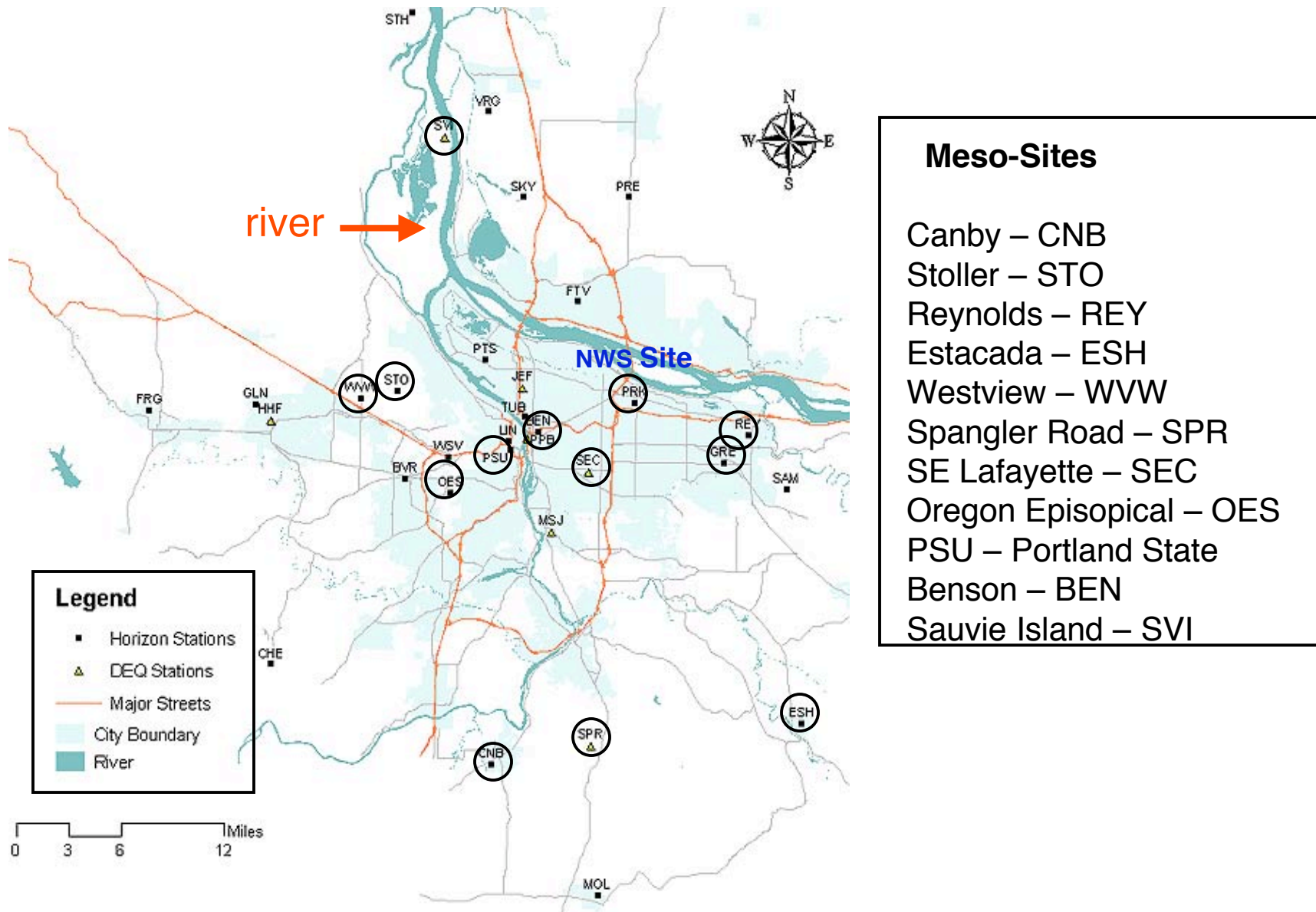


Figure 22. Ozone trend using the three year average of fourth highest eight hour ozone value.

Portland heat wave data: 20-27 July 2006

- NWS 850 hPa & surface charts
- Satellite 250 hPa winds
- Sfc obs from a NWS site & 12 meso-net sites (next map)
 - Temperature at 12 sites
 - Relative Humidity at only 4 sites
- Data in original NWS units for publication in *Weatherwise*
- Simple HI values are calculated, as this is what NWS uses operationally
- Kalkstein HI requires long term data sets not available for Portland meso-met sites

12 meso-sites with temp data (circles) + NWS Air Port site



Eq. for HI ($^{\circ}\text{F}$) uses data from the 13 sites
(tabular form of Eq is in next graph)

$$\text{HI} = c_1 + c_2 \cdot T + c_3 \cdot R + c_4 T \cdot R + c_5 \cdot T^2 + c_6 \cdot R^2 \\ + c_7 \cdot T^2 \cdot R + c_8 \cdot T \cdot R^2 + c_9 \cdot T^2 \cdot R^2$$

where

T = temp ($^{\circ}\text{F}$)

R = relative humidity (%)

$c_1 = -42.379$ ($^{\circ}\text{F}$)

$c_2 = 2.04901523$

$c_3 = 10.14333127$ ($^{\circ}\text{F}$)

$c_4 = -0.22475541$ ($^{\circ}\text{F}$)

$c_5 = -6.83783 \times 10^{-3}$ ($1/^{\circ}\text{F}$)

$c_6 = -5.481717 \times 10^{-2}$ ($^{\circ}\text{F}$)

$c_7 = 1.22874 \times 10^{-3}$ ($1/^{\circ}\text{F}$)

$c_8 = 8.5282 \times 10^{-4}$

$c_9 = -1.99 \times 10^{-6}$ ($1/^{\circ}\text{F}$)

HI (°F) = f (T, RH); table from NOAA website

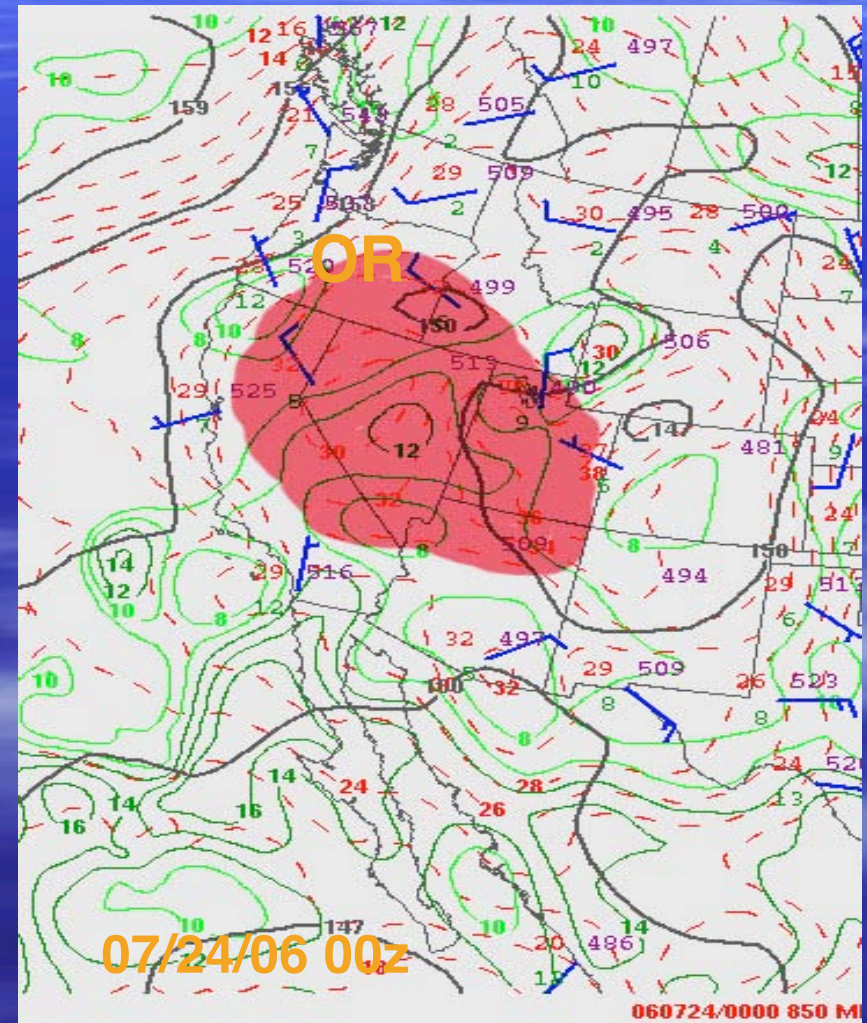
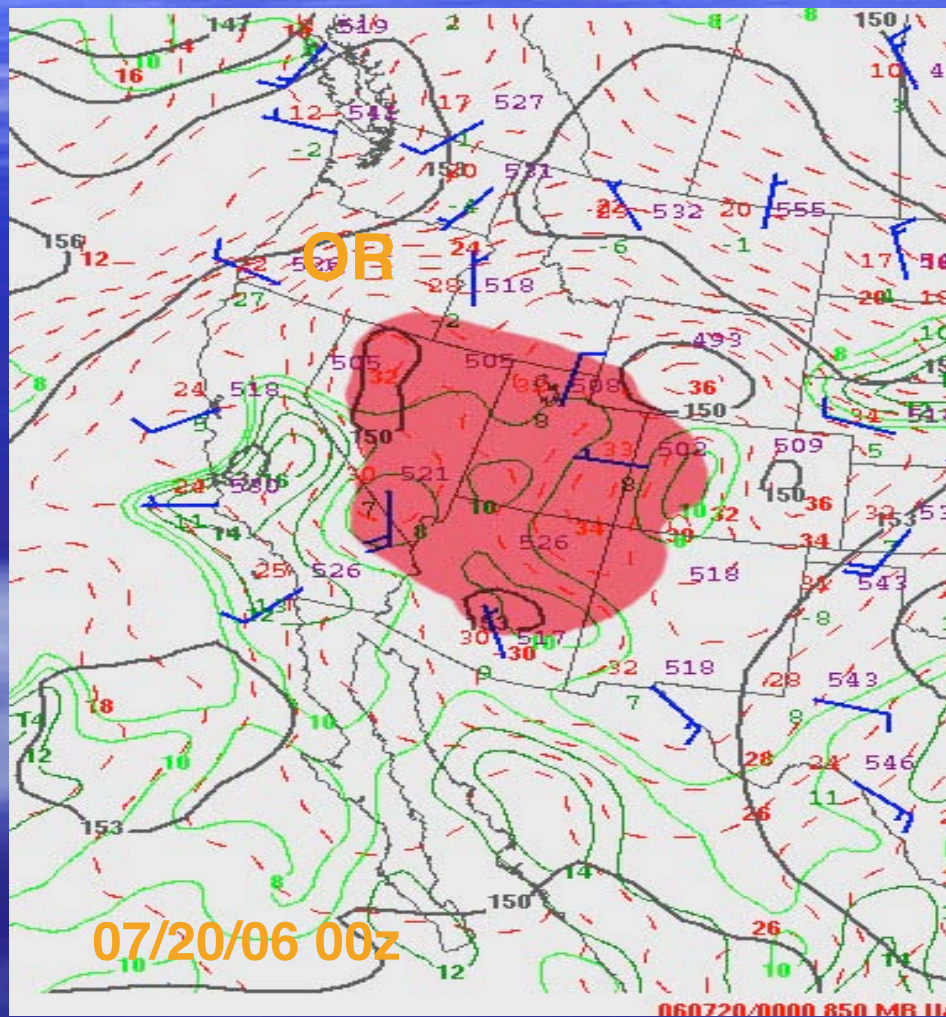
		Temperature (°F)															
		80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
Relative Humidity (%)	40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
	45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
	50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
	55	81	84	86	89	93	97	101	106	112	117	124	130	137			
	60	82	84	88	91	95	100	105	110	116	123	129	137				
	65	82	85	89	93	98	103	108	114	121	128	136					
	70	83	86	90	95	100	105	112	119	126	134						
	75	84	88	92	97	103	109	116	124	132							
	80	84	89	94	100	106	113	121	129								
	85	85	90	96	102	110	117	126	135								
	90	86	91	98	105	113	122	131									
	95	86	93	100	108	117	127										
	100	87	95	103	112	121	132										

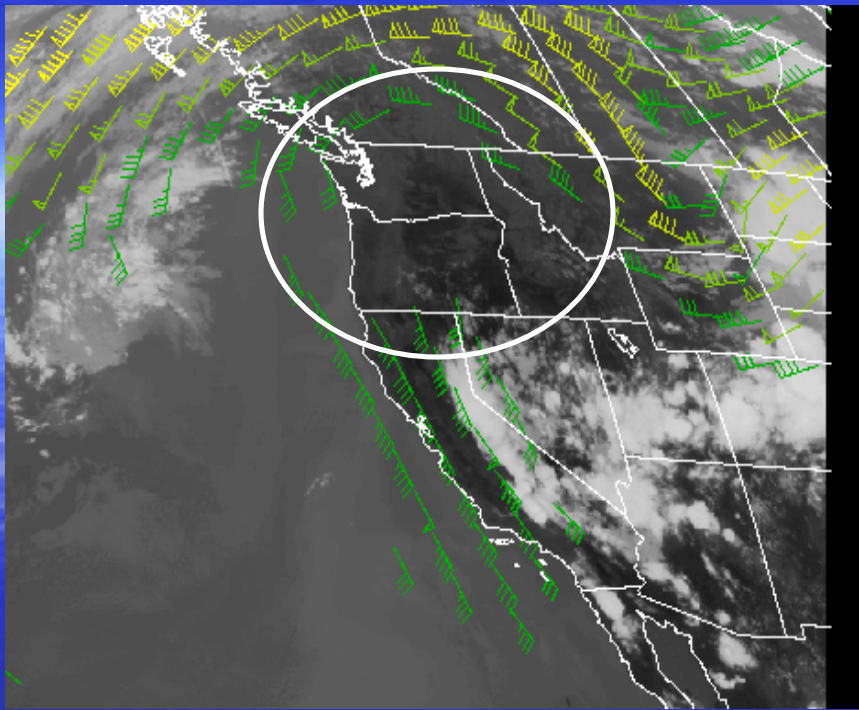
Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

 Caution
 Extreme Caution
 Danger
 Extreme Danger

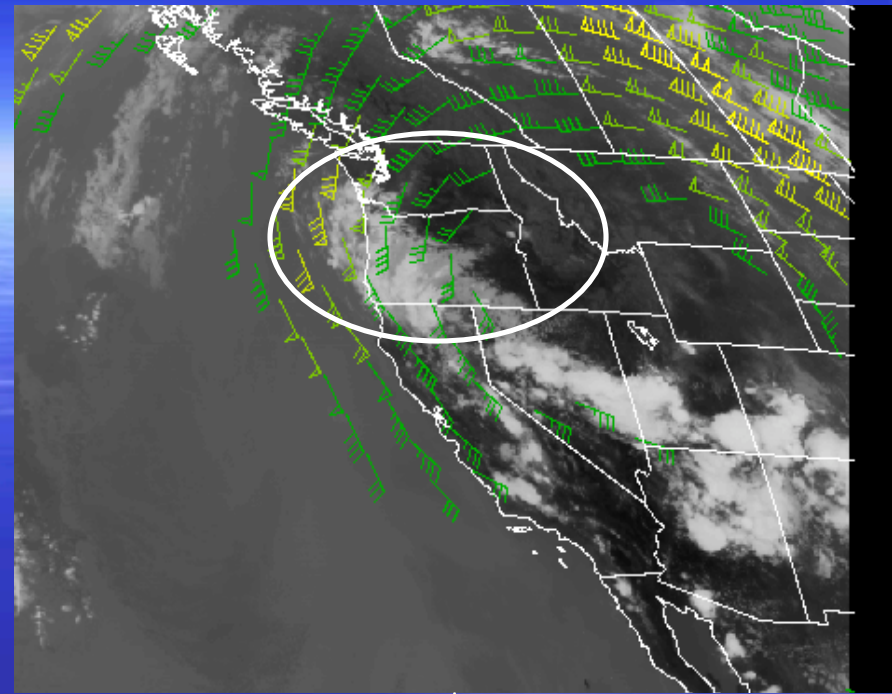
- Numbers in blue box = HI values < observed Temp
- HI only calculated for T > 75 F

Synoptic Summary 1: unusually warm 850 hPa air mass
(associated with four-corners high) gradually moves **northward**
to Oregon, producing **weak onshore flow & 4-day heat wave**
(Red regions = $T > 32^{\circ}\text{F}$)

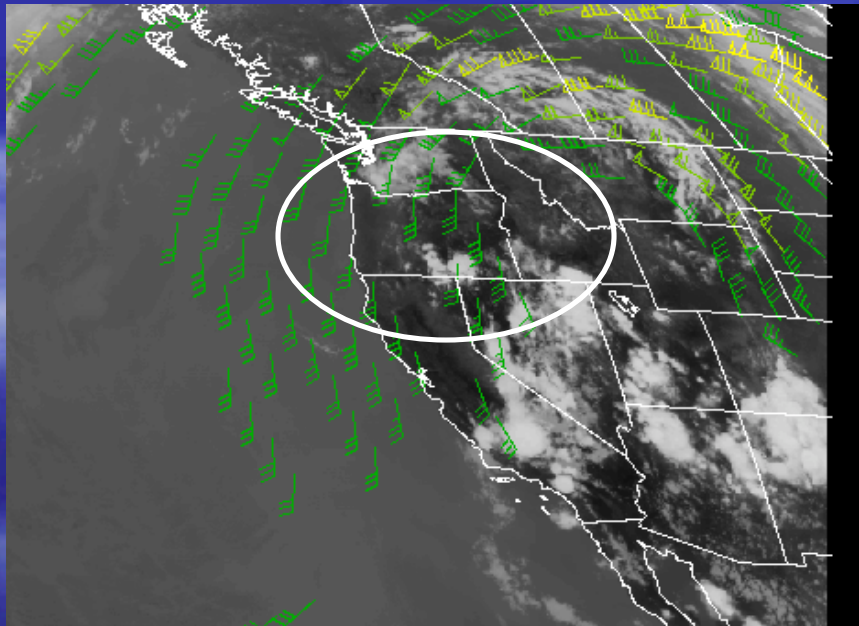




7/21/00z: dry hot air mass over OR; few clouds

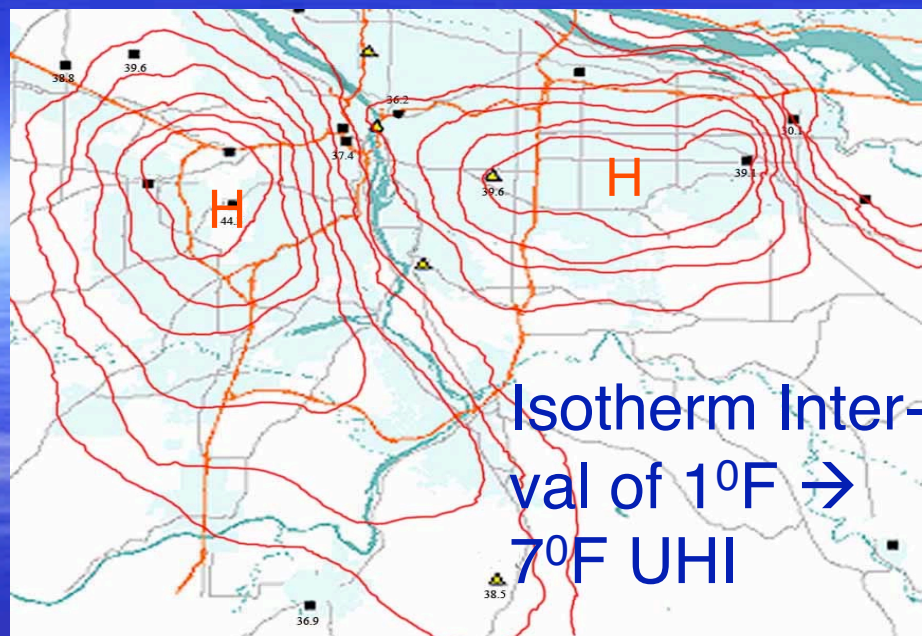


7/22/00z: moist air & clouds come N over OR → high max-night RH & T

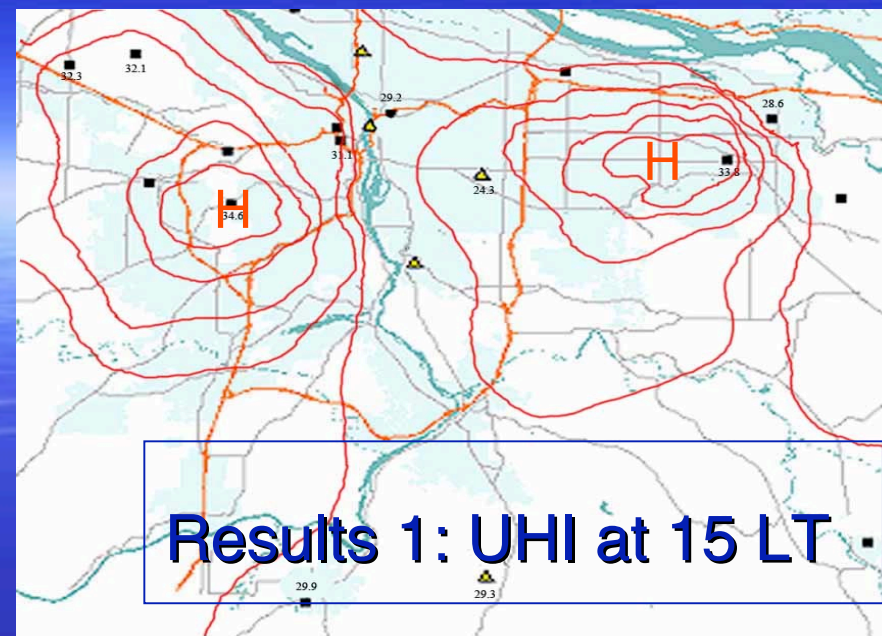
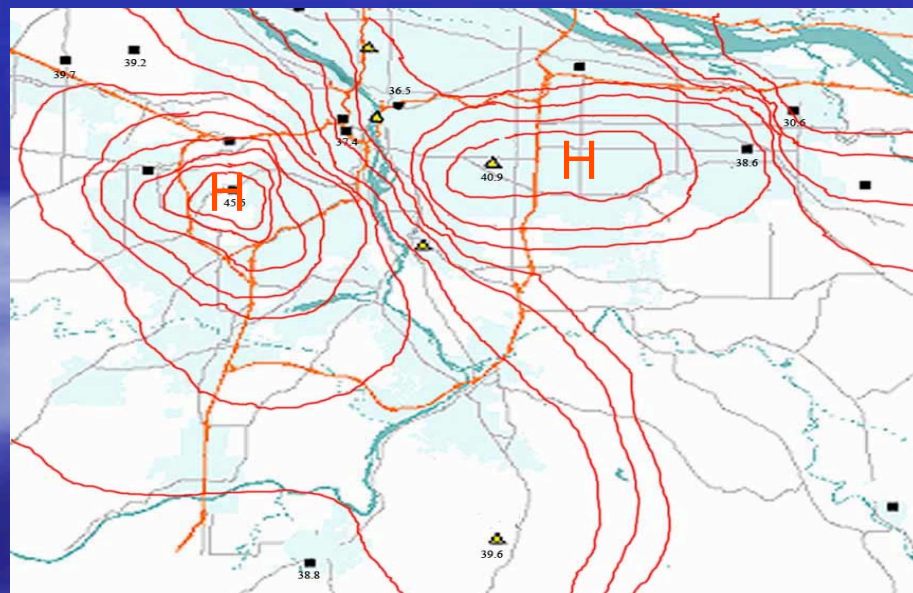


Synoptic Summary 2: Satellite clouds & winds

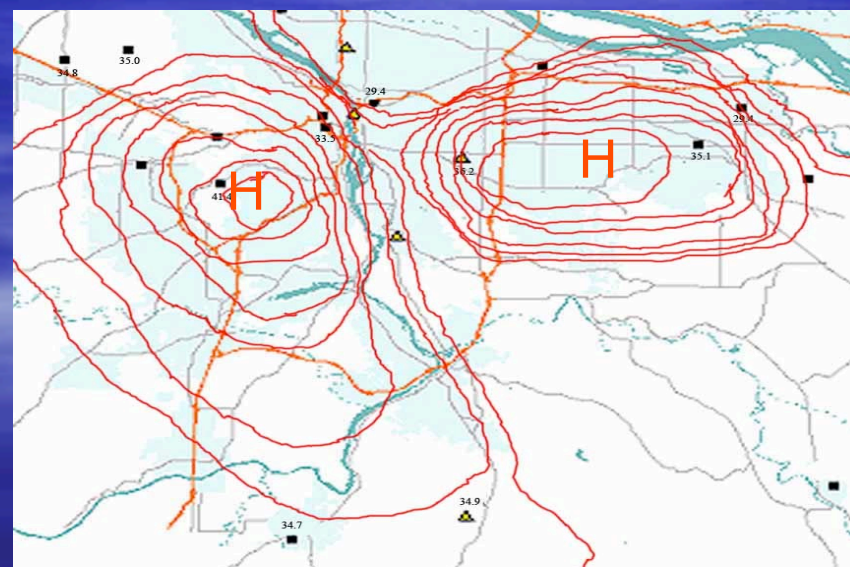
7/23/00z: moist air moves N of OR



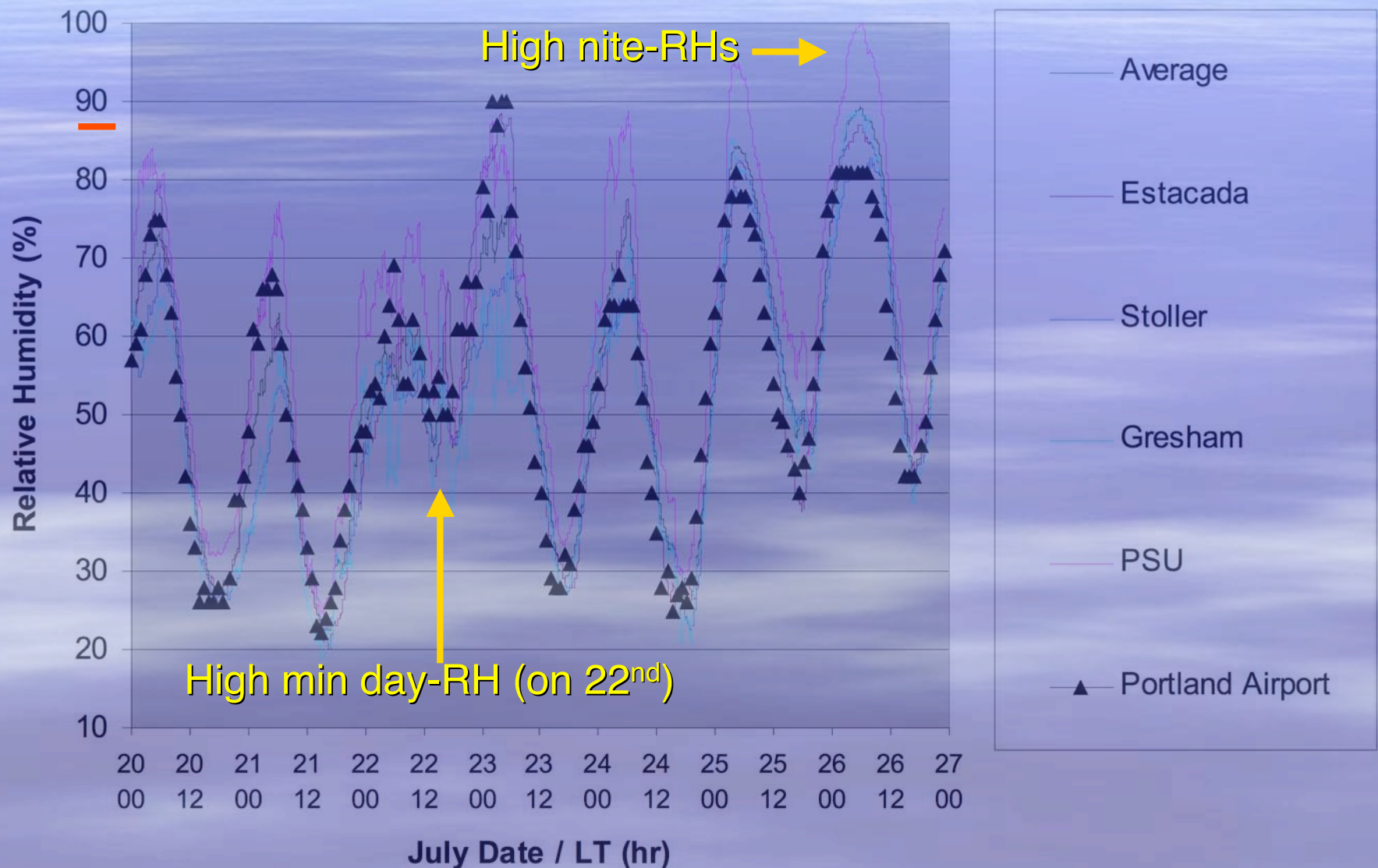
07/2: RH = 23%; V = 13 mph;
Scattered Clouds Max-UHL is west of river



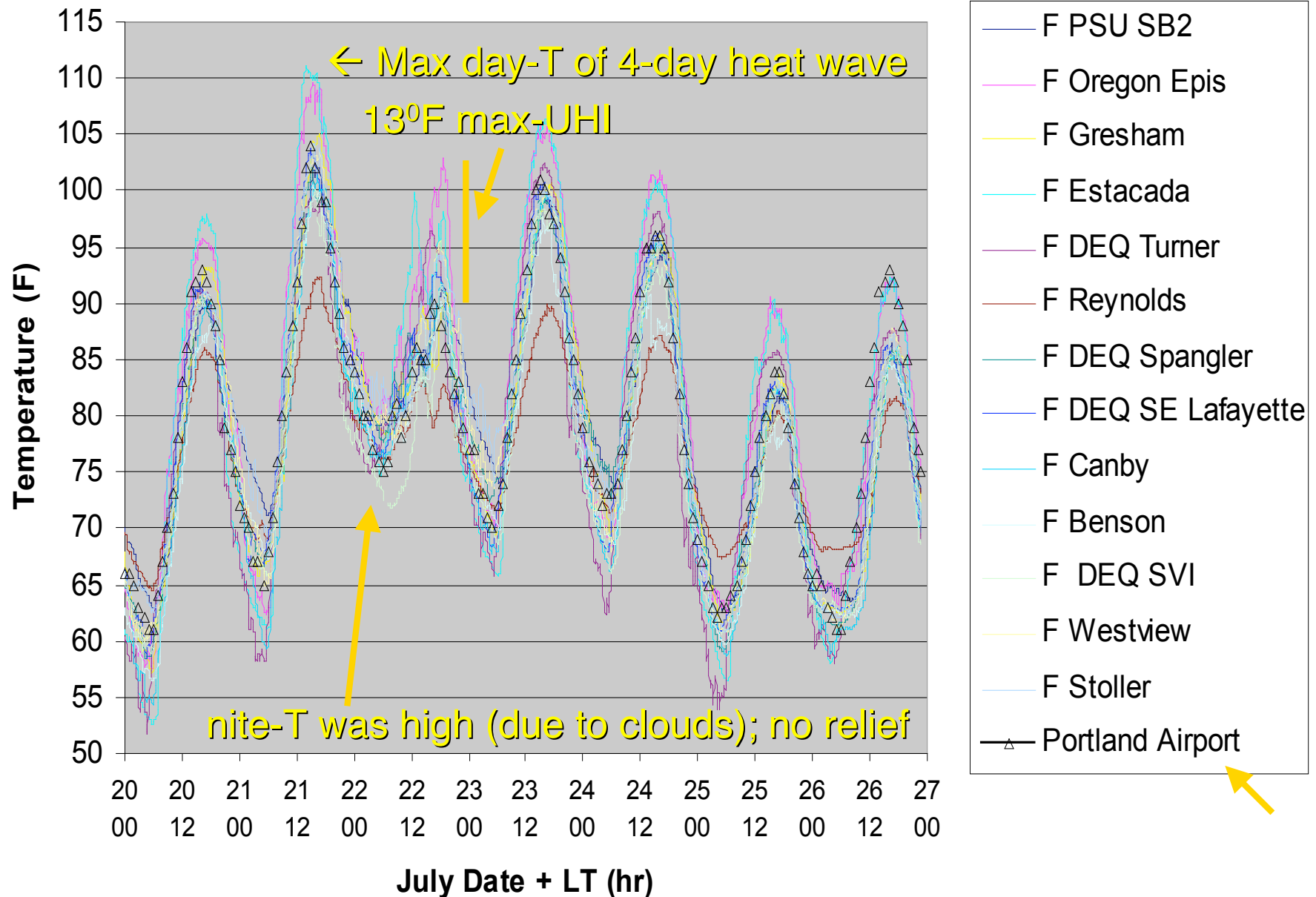
07/22: RH = 52% (max); V = 0 mph; (max coverage)
broken clouds, Left UHI weakens; right one strengthens



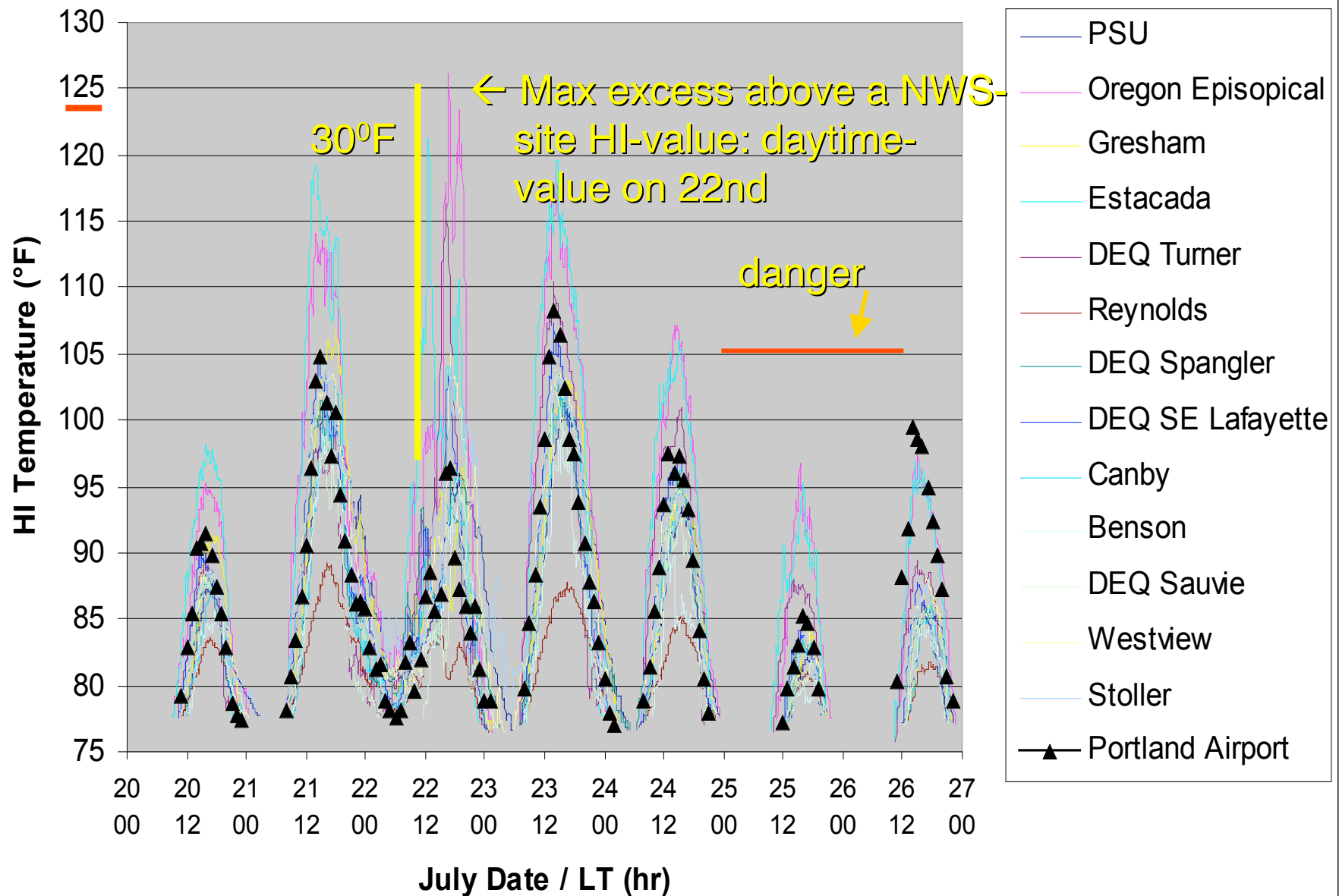
Results 2: RH (t) for the 4 meso-sites with RH obs (& their average) + NWS value (shown as Δ); fairly uniform values across sites; high daytime values



Results 3: T (t) for 12 meso-met sites + NWS site (shown as Δ)

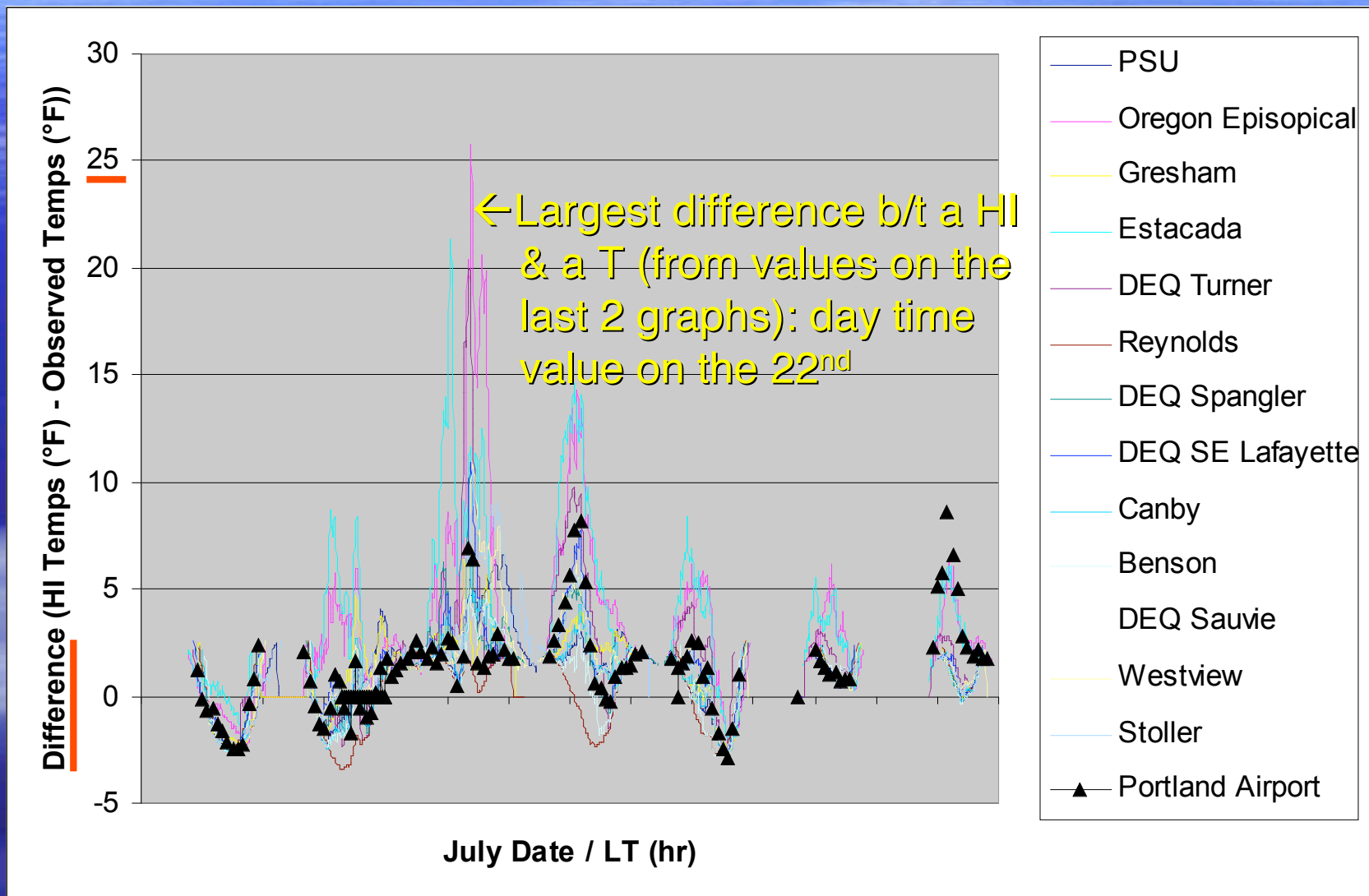


Results 4: HI (t) values for meso sites + NWS site
(Note: orig-T must be ≥ 75 F to get HI-value)



Results 5: $D(t) = HI(t) - T(t)$ values for meso sites + NWS site

Note: low-T & low-RH (see NWS table, above) $\rightarrow D < 0$



Summary

- Portland generally has **mild summer temps & good air quality**
- Synoptic/GC conditions during a four day period in July 2006, however, produced **heat wave & poor air quality** (not shown). **Met factors** included:
 - Warm-moist air **advection**
 - Heavy cloud cover & thus high **nighttime RH**
- Daytime temps were high (max of 111°F), and **remained high** (min of 75°F) during nite of 21st-22nd, due to increased cloud cover

Summary (cont.) & Recommendations

- Portland daytime UHIs were **bisected** by its river
- **Daytime 22 July had the largest**
 - UHI (13°F)
 - **difference** b/t a HI- & a T-value (26°F)
 - **Underestimated HI** value (30°F = 126-96°F); only experienced by people near **this one site**
- **Recommendations**
 - **Weather forecasts** (& forecast models) need to be “urbanized;” e.g., by Taha-Martilli scheme in uMM5
 - **Urban HI-forecasts** must be “urbanized,” by use of observed or “statistical” UHI values



Thanks for listening

QUESTIONS?